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Contact e-mail:
al@kt.dtu.dk

# Glycerol as high-permittivity liquid filler in dielectric silicone elastomers

**Piotr Mazurek (1), Liyun Yu (1), Reimund Gerhard (2), Werner Wirges (2), Anne Ladegaard Skov (1)**

(1) Technical University of Denmark, Danish Polymer Centre, Kgs. Lyngby, Denmark; (2) University of Potsdam, Applied Condensed-Matter Physics, Potsdam, Germany

## Abstract

A recently reported novel class of elastomers was tested with respect to its dielectric properties. The new elastomer material is based on a commercially available polydimethylsiloxane (**PDMS**) composition, which has been modified by embedding **glycerol** droplets into its matrix.[1] The approach has two major advantages that make the material useful in a dielectric actuator. First, the glycerol droplets efficiently **enhance the dielectric constant** which can reach very high values in the composite. Second, the liquid filler also acts as a softener that effectively **decreases the elastic modulus** of the composite. In combination with very **low cost** and **easy preparation**, the two property enhancements lead to a very attractive dielectric elastomer material. Experimental permittivity data are compared to various theoretical models that predict relative-permittivity changes as a function of filler loading, and the applicability of the models is discussed.[2]

Sample names were formed using the pattern: GX_Y_Z, where G and X denote glycerol and the amount of glycerol added to a PDMS prepolymer (weight parts of glycerol per hundred weight parts of silicone prepolymer), respectively, Y corresponds to the PDMS composition employed (S184 – Sylgard 184, XLR630 – Powersil XLR 630), and Z indicates supplementary components (in the approach discussed here, it corresponds to the thinning fluid OS-20).

## Objectives

The aim of this work was to use **polar liquids** as high-permittivity **fillers** for silicone elastomers. The liquid fillers were expected to act similarly to solid fillers and effectively **enhance** the **dielectric constant** of resulting elastomers.

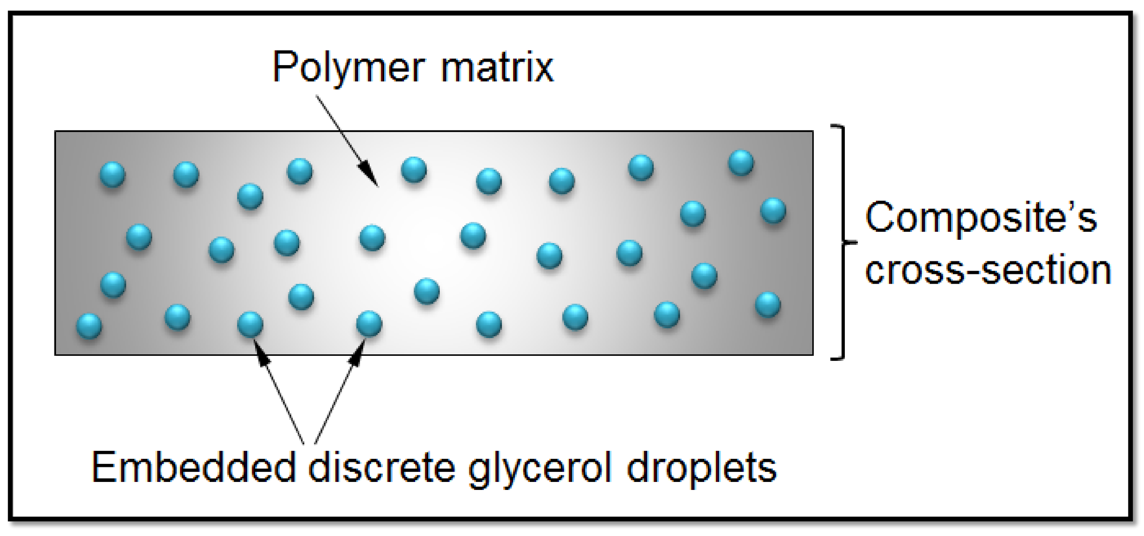


**Figure 1.** Schema of a glycerol-PDMS composite. Glycerol is embedded into a dielectric elastomer in the form of discrete droplets in order to avoid the formation of conductive pathways across the material.

## Film preparation

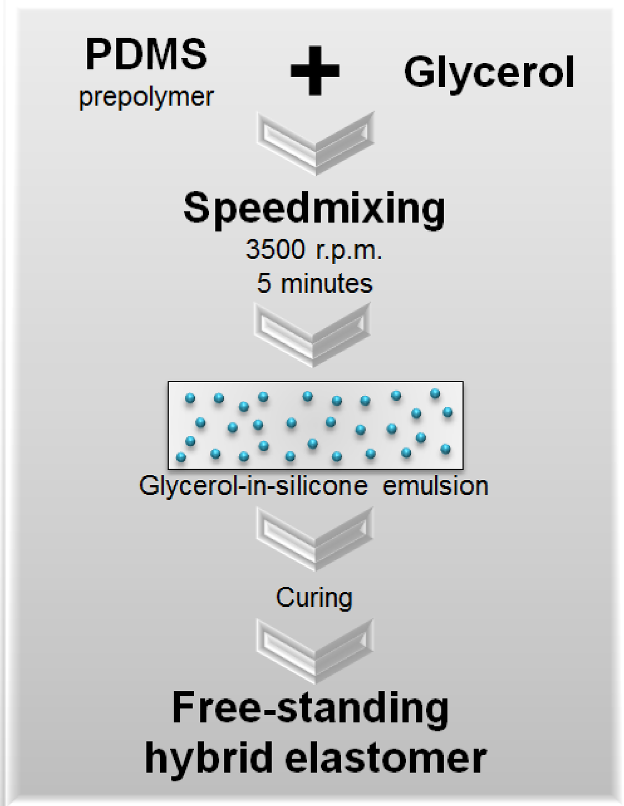


**Figure 2.** Preparation procedure of glycerol-silicone elastomers.

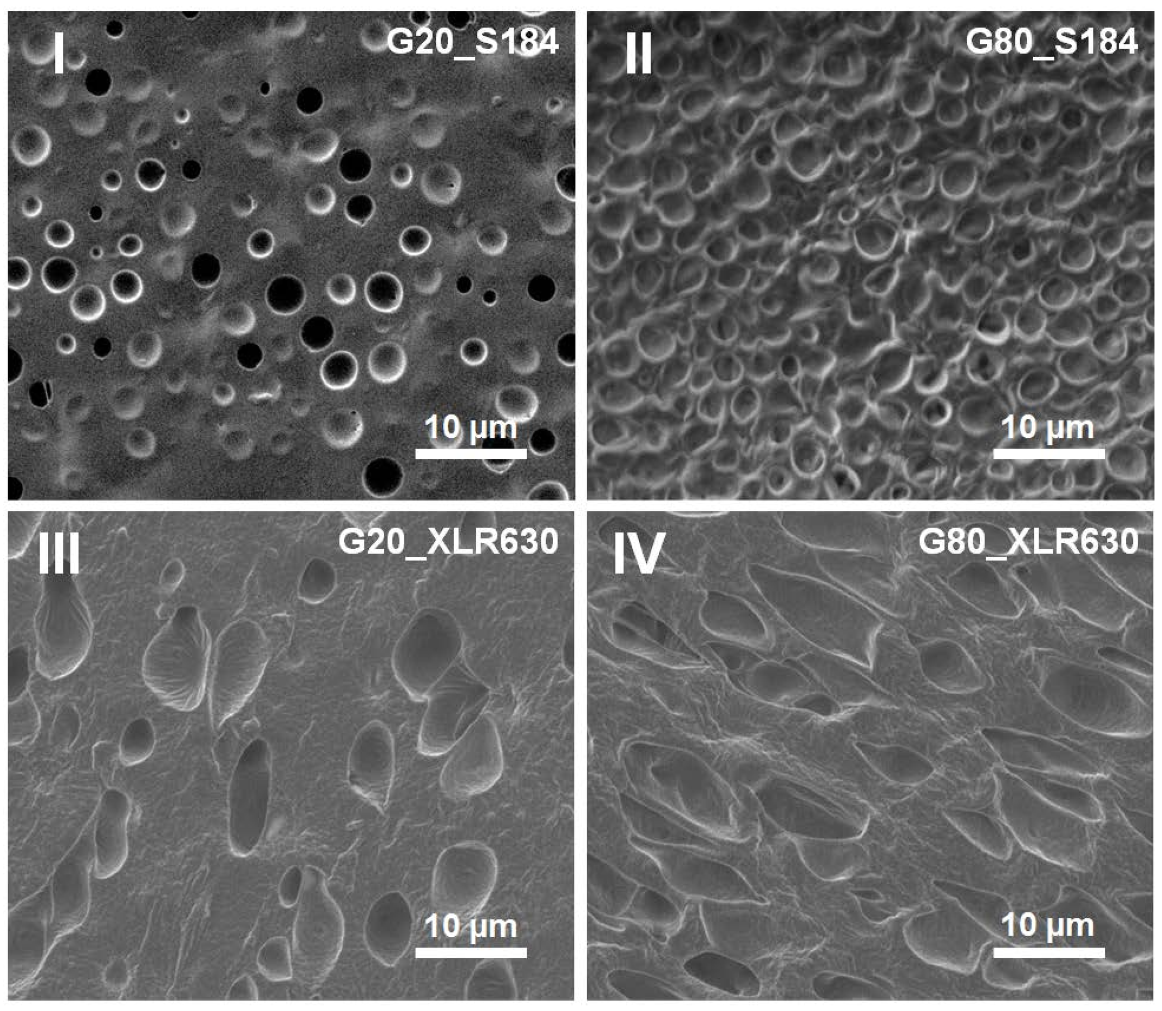


**Figure 3.** SEM images of cured glycerol-PDMS composite cross-sections. I – G20_S184, II – G80_S184, III – G20_XLR630, IV – G80_XLR630.

## Results

**Main findings:**

- The **Young's modulus** of composites **decreases** with increasing glycerol loading yet the ultimate strain remains unaffected
- Glycerol droplets distributed within PDMS act as high-permittivity filler **enhancing the dielectric constant** of resulting composites
- The composites were assessed by means of some of the most popular theoretical models predicting changes of relative permittivities as a function of filler content. Results show that the **formula** suggested by **Jayasundere and Smith** fits the experimental results most accurately

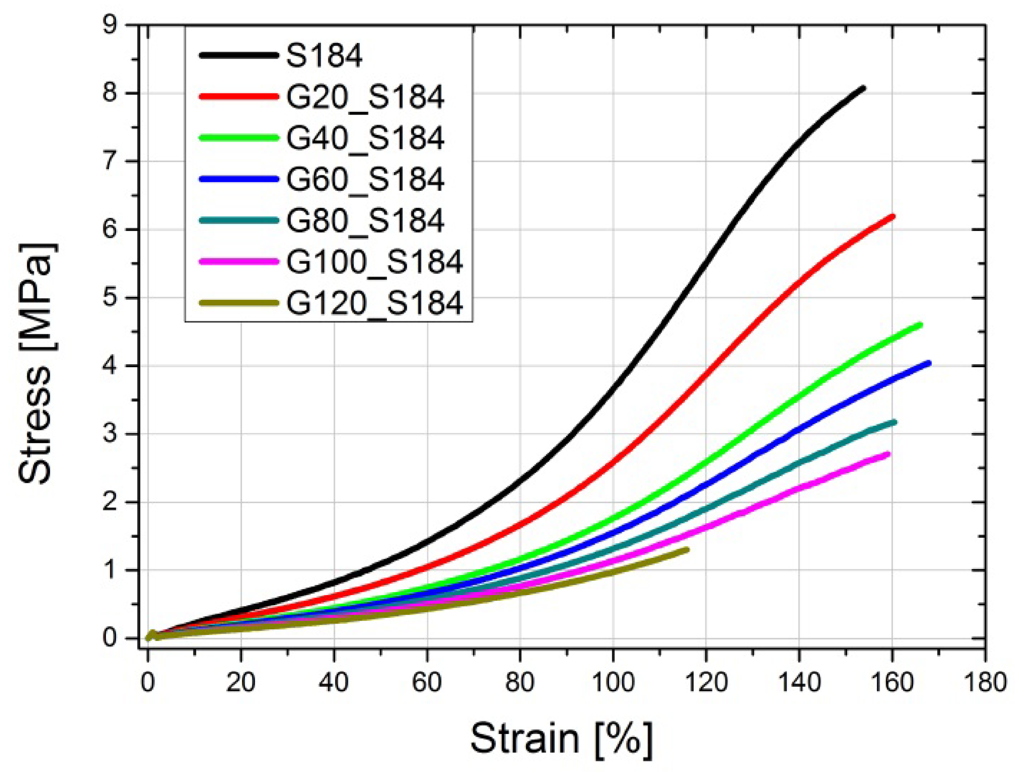


**Figure 4.** Stress-strain behavior of various compositions obtained from tensile measurements.

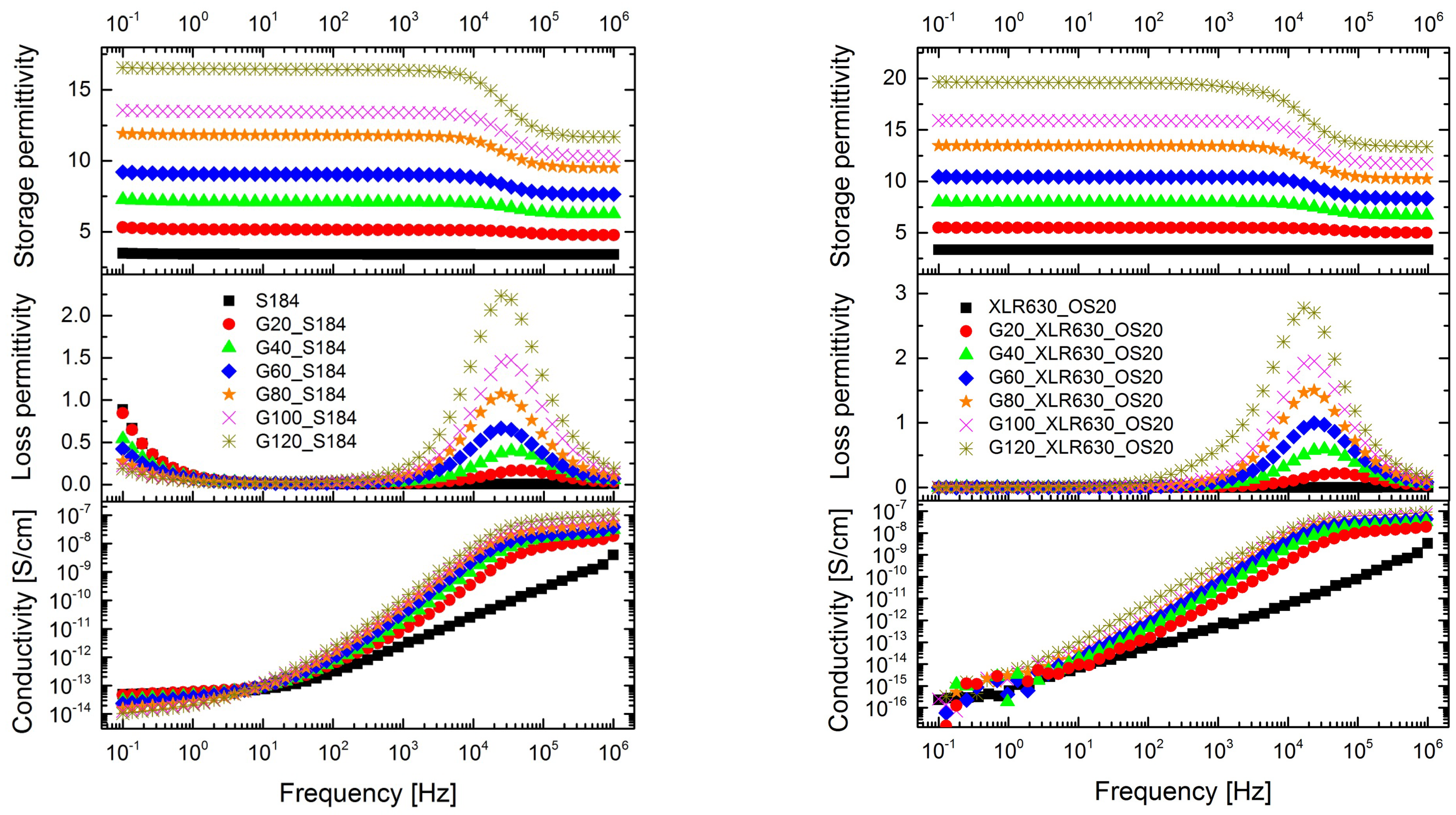


**Figure 5.** Storage permittivity, loss permittivity and AC conductivity of various glycerol-S184 (left) and glycerol-XLR630 (right) composites.

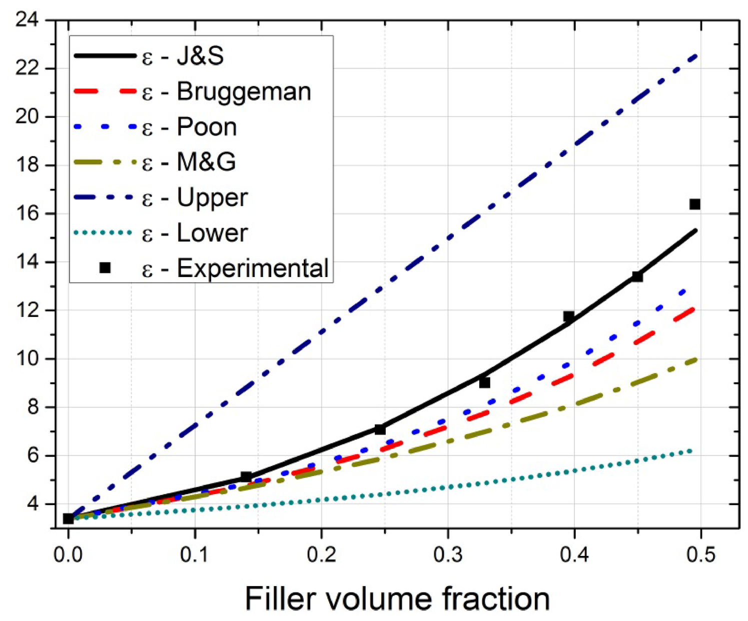


**Figure 6.** Experimental data and theoretical estimate of the relative permittivity at 1 kHz as a function of the glycerol loading in the composites.

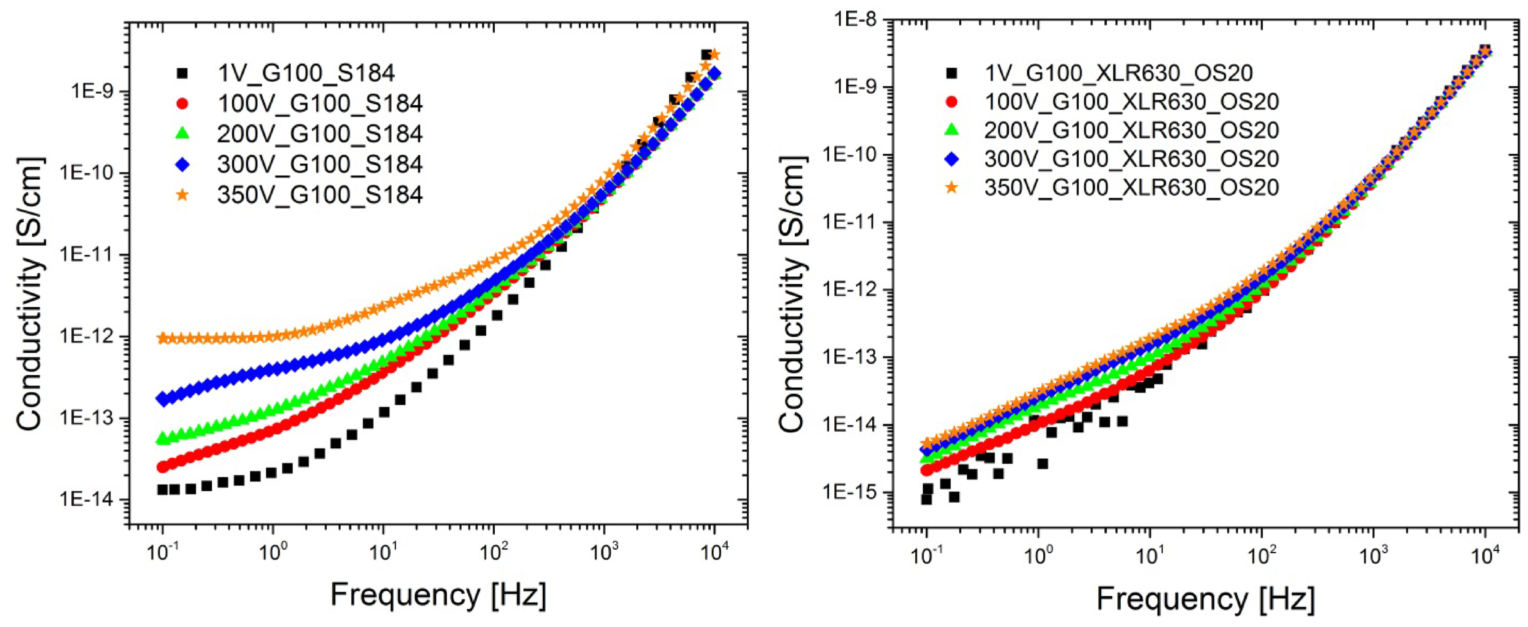


**Figure 7.** Conductivities of composites G100_S184 (left) and G100_XLR630_OS20 (right), for various AC voltages at room temperature.

## Acknowledgments

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## References

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2. P. Mazurek, L. Yu, R. Gerhard, W. Wirges, A.L. Skov, Glycerol as high-permittivity liquid filler in dielectric silicone elastomers, accepted in *J. Appl. Polym. Sci.* in June 2016